OFFICE OF THE LORD PRESIDENT OF THE COUNCIL
MINISTRY OF LABOUR & NATIONAL SERVICE

Scientific and Engineering Manpower in Great Britain

A report on the number and distribution of scientists and engineers now employed in Great Britain, and a study of the likely trend in the future demand for scientific and engineering manpower.

LONDON
HER MAJESTY'S STATIONERY OFFICE
1956
PRICE 1s. 6d. NET

FOREWORD

THIS paper is issued jointly by the Ministry of Labour & National Service and the Advisory Council on Scientific Policy, and embodies the results of two related inquiries.

The first was initiated by the Ministry of Labour which, advised by its Technical Personnel Committee, is responsible for questions affecting the short-term demand for scientific manpower. This inquiry, which was carried out with the help of the Social Survey, is concerned with tbe present number and distribution of scientists and engineers, and with the demands of industry and the other main users of scientific manpower in three years' time. The results of the inquiry are set out in Part II of the paper.

The second study was made by the Committee on Scientific Manpower of the Advisory Council on Scientific Policy, and was based partly on the results of the Ministry of Labour survey and partly on other sources of information. This study is concerned with the likely trend in the long-term demand for scientists and engineers, and the conclusions reacbed are given in Part III of the paper.

It is the responsibility of the Advisory Council "to advise the Lord President of the Council in the exercise of his responsibility for the formulation and execution of Government scientific policy" and the Council bas in particular been asked to make recommendations about "the arrangements for securing an adequate flow of scientific manpower to meet the needs both of Government and of industry". The Advisory Council, in studying the trend of future demand, is thus carrying on the inquiries started by the Barlow Committee whicb reported in 1946 (Cmd. 6824). Their purpose is to facilitate forward planning by giving a broad indication of the requirements likely to arise on the most reasonable assumptions which can be made about the future.

SCIENTIFIC AND ENGINEERING MANPOWER IN GREAT BRITAIN

Part I

Introduction

A continuing shortage of scientific manpower has become a familiar feature of the post-war scene. Its underlying cause is the accelerating pace of economic, political and technical change in the modern world; and its most important manifestation the competition, both within and between industrialised countries, to apply the fruits of new scientific and engineering discovery to production and commerce. Almost every country has had to introduce special educational measures to deal with the situation. In the United Kingdom, the Barlow Committee, appointed in 1945, considered the question of scientific manpower, and recommended that the output of science graduates should be doubled at the earliest possible moment; and that, in discharging this task, the universities should be assured of the necessary assistance from the Exchequer (Cmd. 6824). The Committee also endorsed an earlier recommendation of the Percy Committee on Higher Technological Education, that full-time technological courses of university degree standard should be established at a selected number of technical colleges. Bold though they were, the Committee nevertheless felt that its proposals did not go far enough to assure that the supply of science and engineering graduates would have overtaken demand by the year 1955. Events have more than justified this view.

2. The universities took only four years to implement the main recommendations of the Barlow Committee. Their achievement was all the more remarkable because there was no lowering of educational standards in spite of considerable difficulties over accommodation and staff. In a report (Cmd. 8561) submitted in 1952, the Scientific Manpower Committee of the Advisory Council on Scientific Policy had, however, to reiterate the warning that, in spite of the post-war expansion that had already occurred in the universities, the shortage of practically all kinds of trained scientists and engineers was likely to be an enduring one. In view of the urgent need to increase their number in British industry, the Committee accordingly recommended that every effort should be made to increase the supply, with particular emphasis on chemists, chemical engineers, electrical engineers, mechanical engineers and physicists. These conclusions were endorsed by the Advisory Council on Scientific Policy, and since then plans to strengthen the engineering and scientific departments in a number of universities, including the Imperial College of Science and Technology, have been set in motion with the help of funds specially voted for the purpose. The Government has also recently announced a programme for the development of the technical colleges of the country, including the up-grading of a number of institutions into colleges of advanced technology (Cmd. 9703). As the universities are now submitting to the University Grants Committee proposals for further expansion during the course of the quinquennium 1957/62, the time seemed appropriate for the Committee on Scientific Manpower to attempt a more precise assessment of the likely demand for trained scientists and engineers over the period ending in 1970.

3. This was made possible by the fact that the Ministry of Labour had embarked, with the help of the Social Survey, upon an inquiry into the number of scientists and engineers now employed by manufacturing industries and into employers' estimates of requirements in three years' time. The investigation has since been

extended to cover other sectors of the economy. The need for information of this kind had been recognised in previous inquiries into the subject. But, for want of better data, earlier estimates, such as that of the Barlow Committee in 1946, have had to be based mainly on an actuarial analysis of the number of diplomas and university degrees which have been awarded by the technical colleges and universities over the past thirty years or so.

4. The purpose of the Committee on Scientific Manpower's present exercise has been to set a goal for the universities and the technical colleges in order that present and future demands for trained scientific manpower should be met. Much has been written and said in recent months about the relative weakness of the British effort in higher education in science and technology, in comparison with that of certain other countries. The Committee has been kept informed about all the available facts, but, in the absence of any yardstick by which to measure the relative standards of education in different countries, it has not attempted, in reaching its own conclusions, to use the information which forms the basis of these international comparisons.

5. The new data on which the Committee's analyses have been based, and which have been provided by the Ministry of Labour's inquiry, constitute the most reliable information that has yet become available about the number employed as scientists and engineers in Great Britain. Whatever faults the present assessment of future needs may prove to have, it is thus at least more firmly based than those by which it has been preceded. On the other hand, since they provide the source of all future calculations, it is necessary to be quite clear about the fields which the figures cover, and those which have been omitted.

Definitions

6. A previous Report by the Committee on Scientific Manpower (Cmd. 8561) used the term "scientist" in a general way to signify a man or woman trained either in fundamental or applied science to the level of a university degree or equivalent qualification. That report related both to research workers engaged in extending the boundaries of fundamental knowledge and to the much larger number of scientists, in engineering and other technologies, whose task it is to apply the fruits of research to practical ends. In the sense of this definition, the term "scientist" covers the definition of technologist given in the Government's recent White Paper on Technical Education (Cmd. 9703): "a technologist has the qualifications and experience required for membership of a professional institution. Most university graduates in engineering and other applied sciences, and a good proportion of holders of Higher National Diplomas or Certificates or similar qualifications, become technologists".

In the present inquiry, we have reverted to the use of the two terms "scientist" and "engineer" to cover the basic sciences on the one hand, and the applied sciences in the engineering field on the other. Following the practice usual in university statistics, metallurgy is included with engineering under applied science. The term "scientist" in this report covers the following disciplines:

biology (all branches)
chemistry (other than pharmacy)
geology
mathematics
physics
general science

while the term "engineer" covers people with a degree or other professional qualification in:

chemical engineering
civil and structural engineering

electrical engineering
mining engineering
mechanical, aeronautical and other engineering
metallurgy

We wish to emphasise that the terms "scientist" and "engineer", as used in this report, refer only to people with qualifications in the subjects listed above. They exclude people who have studied science at the universities but qualified in other fields, notably agricultural science, medicine, dentistry and veterinary science. The report does not include people with specialised qualifications in certain fields of technology, e.g. textiles and rubber; nor does it include the social sciences.

7. In this report we have concentrated attention on the demand for "qualified" scientists and engineers. Any definition of the term "qualified" must be arbitrary. For the purpose of this report it includes people who have a university degree in science or engineering, or are associates of certain bodies such as the Manchester College of Technology, or are corporate or graduate members of the professional institutions listed in Appendix I. This was the definition adopted in the questionnaires issued by the Ministry of Labour and the Social Survey. In those questionnaires, information was also sought separately about the number of electrical and mechanical engineers with qualifications not going beyond the Higher National Certificate or the Higher National Diploma, but we have not attempted any specific estimate of future demand for such categories.

Part II

Present Distribution of Scientists and Engineers and Stated Requirements in 1959

RESULTS OF THE MINISTRY OF LABOUR INQUIRY

Scope of the inquiry

8. The objects of the Ministry of Labour's inquiry were first, to discover the number and distribution of scientists and engineers already in employment; and second, to obtain an idea of the additional number that would be required by the end of the next three years. A period of three years was chosen as being the furthest ahead employers, in general, could be expected to forecast their probable requirements.

9. The inquiry into the employment of scientists and engineers in the private sector of the manufacturing and building and contracting industries was carried out by the Social Survey, and was linked with an inquiry on behalf of the Department of Scientific and Industrial Research into the proportion of industry's resources spent on research. Information was sought from all manufacturing establishments employing 500 workers or more, and from a sample of those with between 100 and 499 workers. Establishments with less than 100 workers were not approached. In the building and contracting industry the sampling arrangements were slightly different. Fuller details are given in Appendix V.

10. The Ministry also obtained information from the boards of nationalised industries, central Government Departments and Local Authorities. The Department of Scientific and Industrial Research supplied information about the number employed in industrial research associations. Statistics regarding teachers of science and engineering in schools, colleges and universities were supplied by the Education Departments and the University Grants Committee.

11. Agriculture, the non-nationalised parts of the mining and transport industries, shipping, the distributive trades and miscellaneous service industries were not covered by the inquiry. Self employed persons and persons employed by firms of consultants were also excluded.

Scientists and engineers employed in Great Britain

12. The following table summarises the information that was obtained as a result of the inquiry. A more detailed analysis is given in Appendix II.

Employment of Scientists and Engineers in early 1956 (excluding the employments shown in paragraph 11, and manufacturing and building and contracting establishments with less than 100 workers)

	Qualified Scientists	Qualified Engineers	Total Qualified Scientists and Engineers	Total number of Engineers with H.N.C., H.N.D., or equivalent only[3]
Manufacturing Industry[1] ..	17,050	37,000	54,050	22,790
Nationalised Industries[2]	2,420	14,660	17,080	5,330
Central Government	5,800	8,050	13,850	1,710
Local Authorities	350	6,330	6,680	320
Education	25,610	2,430	28,040	—
Total	51,230	68,470	119,700	30,150

[1] Including the building and contracting industry, and industrial research associations.
[2] Including Atomic Energy Authority.
[3] Except where stated to the contrary, all the figures in this report relate to *qualified* scientists and engineers.

The figures above may include a number of scientists and engineers working abroad for British firms, but, in general, persons working abroad have been excluded. No allowance has been made for people working in H.M. Oversea Civil Service or in temporary Government employment abroad.

13. Rough estimates have been made of the number of scientists and engineers in employment not covered by the inquiry, i.e. those employed by manufacturing and building and contracting firms with less than 100 workers, those in the industries and occupations mentioned in paragraph 11 and those in the regular Armed Forces. On the basis of these estimates, which are necessarily imprecise, the total number of qualified scientists and engineers as defined in paragraph 6 in employment in Great Britain is approximately as follows:

	Qualified Scientists	Qualified Engineers	Total
(*a*) In employment covered by the inquiry	51,230	68,470	119,700
(*b*) In other employment	5,000	10,000	15,000
Grand Total	56,230	78,470	134,700

This grand total has been taken as the basis of the long-term estimates made in Part III of this paper. It excludes about 4,700 qualified scientists and 2,300 qualified engineers not in employment but engaged in post-graduate research at the universities or on National Service. It also excludes the important categories referred to in the final sentence of paragraph 6.

14. Of the total 134,700 qualified scientists and engineers, about 43 per cent are in manufacturing industry, 12½ per cent in the nationalised industries, 21 per cent in teaching, 10 per cent in central Government, 5 per cent in local Government, and 8 per cent in miscellaneous occupations. Nearly half of the qualified scientists are engaged in teaching and three-quarters of the qualified engineers are in industry.

15. The number of qualified scientists and engineers in Great Britain, dealt with in this report, represents approximately 0·6 per cent of the total working population of 24 millions. In addition there are 30,150 engineers with no higher

qualification than Higher National Certificate, Higher National Diploma or the equivalent, nearly all of whom are employed in industry.

The distribution of scientists and engineers between industries

16. Tables I and II of Appendix III give a detailed analysis of scientists and engineers employed in various groups of manufacturing industry, and in the nationalised industries.

17. The striking feature of the distribution of qualified scientists and engineers between industries (both publicly and privately owned) is their concentration in a relatively few industrial groups. Of the total of 48,800 qualified scientists and engineers in the manufacturing industries shown in Table I of Appendix III the following industry groups, accounting for only three-tenths of the total employed, include very nearly two-thirds of the scientists and engineers:

Chemicals (IVa)	8,300
Other plant and machinery (VIc)	6,700
Electrical engineering (VIe)	12,200
Aircraft manufacture (VIIb)	4,300

18. The proportion of qualified scientists and engineers to total number employed varies widely from one industry to another. The highest proportions are:

	Per cent
Atomic Energy Authority	10·9[1]
Mineral oil refining	5·2
Electricity authorities	2·9
Chemical and allied trades	2·7
Electrical engineering	2·0
Aircraft manufacture	1·9
Constructional engineering	1·5
Gas Council and Area Boards	1·2
Non-ferrous metal manufacture	1·1
Rayon, nylon, etc.	1·1
Other plant and machinery	1·0
Average for all industries	0·8

[1] The high percentage is partly due to the fact that the Atomic Energy Authority is primarily a research and development and pioneering organisation.

In none of the other industries covered by the inquiry is the proportion as much as 1·0 per cent. In two major industries—shipbuilding and motor manufacture—the proportion is 0·4 per cent. Some industries, e.g. cotton, wool and wood, cork, paper and printing have less than 0·25 per cent. It should be noted, however, that the inquiry does not cover specialised qualifications such as those held by textile technologists.

19. The employment of scientists and engineers in industry by profession is shown in Appendix IV, Tables I and II.

The distribution of scientists and engineers outside industry

20. Of the 13,850 scientists and engineers in Government employment, just over one-half are in the defence departments (including the Ministry of Supply), just over a quarter in the civil departments and one-sixth in the research departments.*

* The Department of Scientific and Industrial Research, Agricultural Research Council, Medical Research Council and the Nature Conservancy.

Of the 6,680 qualified scientists and engineers employed by local authorities (other than for teaching), the great majority are civil engineers (80 per cent of the total). Table III of Appendix IV shows the distribution of scientists and engineers in Government and Local Authority employment by profession.

21. There are about 25,600 qualified scientists engaged in teaching, and about 2,400 engineers. Of this total 13 per cent are in the universities and the remainder in schools, technical colleges, teachers' training colleges and other further educational establishments. The number in Scottish schools, etc., is just over a quarter of the number in schools, etc., in England and Wales, because in all secondary schools in Scotland teachers of mathematics or science are normally required to be graduates. The distribution of scientists and engineers engaged in teaching is shown in Appendix IV, Table IV.

Types of work done by scientists and engineers in industry

22. The inquiry form sent to industrial establishments asked for the number of scientists and engineers employed to be sub-divided under three heads, viz. (1) those employed on research and development, (2) those employed on manufacture, production, operation, maintenance and installation, and (3) those employed on other work.

23. Of the total of qualified scientists and engineers employed in manufacturing industry, covered by the inquiry, about 45 per cent were shown to be engaged in research and development, 47 per cent in production, maintenance and installation, and the remainder (8 per cent) in "other work". The heading "other work" covers about 4,100 people of whom a large proportion may not be engaged directly on any form of scientific or engineering work. The figures are given in detail for each manufacturing industry in Table I of Appendix III. Comparable figures for all the nationalised industries are not available; the figures that are available are given in Appendix III, Table II.

24. The allocation of staff between these functions must have presented considerable difficulty and comparability of definition cannot be assumed. So far as the figures go, they suggest:

(i) well above average proportions engaged in research and development in the following industries:
- aircraft
- electrical engineering
- precision instruments, etc.
- rayon, nylon, etc.;

(ii) well below average proportions engaged in research and development in the following industries:
- shipbuilding and repairing
- railway equipment
- iron and steel
- non-ferrous metal
- other plant and machinery.

Demand for scientists and engineers in the next three years

(a) Requirements reported by industry

25. Employers were asked to estimate the number of qualified scientists and engineers in each category that they aimed to employ three years hence, on the assumption that the required number of recruits would be forthcoming. They were not asked to provide such information in respect of persons holding only Higher National Certificates or Higher National Diplomas. The requirements summarised below are given in fuller detail in Tables I and II of Appendix IV.

	Number employed 1956	1959 requirements stated by employers	
		Number	% increase over 1956
Manufacturing Industry	48,800	67,000	37
Building and Contracting	3,800	5,000	32
Research Associations	1,400	1,740	24
Nationalised Industries and Atomic Energy Authority*	17,100	20,900	22
Total industry*	71,100	94,640	33

* In estimating 1959 requirements an arbitrary increase of 30 per cent over 1956 has been assumed as regards scientists and engineers employed by the Atomic Energy Authority. (See Appendix IV, Table II, Note [1].)

26. In considering these statements of demand in 1959 it should be noted that employers' estimates have presumably included not only an allowance for growth of output during the next three years but also some allowance to meet an existing shortage of qualified scientists and engineers.

(*b*) *Requirements of Central Government, Local Authorities and Teaching*

27. Requirements reported by Government Departments, Local Authorities, Education Departments, and the University Grants Committee are as follows:

	Present numbers	Estimate of 1959 requirements	% increase over 1956
1. Central Government[1]			
(*a*) Defence Departments ..	7,600	8,500	12
(*b*) Civil Departments	3,900	4,450	14
(*c*) Research Departments ..	2,350	2,900	23
Total	13,850	15,850	14·5
2. Local Authorities[2]	6,700	8,500	27
3. Teaching			
(*a*) Universities[3]	3,250	4,350	34
(*b*) Schools, etc.	24,800	26,700	8
Total..	28,050	31,050	11
Grand Total..	48,600	55,400	14

[1] The estimates for 1959 were made on the policies existing at 1st January, 1956, i.e. before the decision to make a 10–15,000 reduction in the size of the Civil Service and a £100 million reduction in Government expenditure.

[2] Excluding Local Education Authorities.

[3] University requirements in 1959 were estimated before the University Grants Committee had received the Universities' estimates for 1957–62 and are conjectural.

28. Of the Central Government's future requirements, those of the Research Departments represent the greatest expansion. The requirements of Government Departments as a whole increase considerably less, proportionately, than those reported by industry. The future needs of Local Authorities are mainly for civil engineers.

Future requirements by categories of scientists and engineers

29. Estimates of requirements in 1959 by categories of scientists and engineers are given by industry groups, and for Government Departments, Local Authorities and teaching in Tables I–IV of Appendix IV. Summarised, the figures are as follows:

	Number employed in 1956	Estimated demand in 1959	Increase over 1956	Percentage increase over 1956
(*a*) Scientists[1]				
Biologists	4,800	5,400	600	12·5
Chemists	20,700	25,200	4,500	22
Geologists	900	1,100	200	22
Mathematicians	11,500	13,000	1,500	13
Physicists	10,500	12,900	2,400	23
Other Scientists	2,800	3,100	300	11
Total Scientists	51,200	60,700	9,500	18·5
(*b*) Engineers[1]				
Chemical Engineers	1,500	2,200	700	47
Civil Engineers	12,800	16,200	3,400	27
Electrical Engineers	17,800	22,900	5,100	29
Mining Engineers	3,800	4,800	1,000	26
Mechanical and other Engineers	27,000	35,800	8,800	33
Metallurgists	3,200	4,400	1,200	38
Engineers in teaching[2]	2,400	3,000	600	25
Total Engineers[1]	68,500	89,300	20,800	30
(*c*) Total Scientists and Engineers[3]	119,700	150,000	30,300	26

[1] See note * to paragraph 25.
[2] No complete breakdown is available.
[3] In employment covered by this inquiry.

30. Amongst scientists the greatest demand numerically in the next three years is for chemists. Amongst engineers the greatest demand in numbers is for mechanical and other engineers, but an increase of 47 per cent is required in chemical engineers and 38 per cent in metallurgists.

Disparities between present and past estimates of the number of qualified scientists and engineers

31. Excluding the categories referred to in the last sentence of paragraph 6, but including the 7,000 on National Service or engaged on post-graduate research, the total number of qualified scientists and engineers in Great Britain is estimated (see paragraph 13) to be about 61,000 and 81,000 respectively. Even if the estimate of 5,000 scientists in the fields of employment not covered by the inquiry is conservative, there is still a substantial gap between the present count of qualified scientists and the numbers shown in previous inquiries. As far back as 1946 it was estimated in the Barlow Report (Cmd. 6824) that there were then 55,000 scientists, and a later estimate gave a figure for 1954 of 78,000 scientists.*

32. One source of difference arises from the omission from the 1956 survey of scientists working abroad. It is possible also that insufficient allowance had been made in previous estimates for women science graduates who were no longer in employment. But the greater part of the difference is probably to be accounted

* O.E.E.C.: Report on Shortages and Surpluses of highly qualified scientists and engineers in Western Europe.

for by science graduates who have taken employment in other fields, for example men with degrees in physics now classified as engineers, or mathematicians now working as actuaries, or by men and women with qualifications in science now in employment in which such qualifications are not demanded.

33. The number of qualified engineers revealed by the inquiry agrees reasonably well with other calculations based upon the number of past awards of university degrees and corresponding qualifications in the engineering sciences.

Part III

The Long-Term Demand for Scientists and Engineers

ASSESSMENT BY THE COMMITTEE ON SCIENTIFIC MANPOWER

Basis of assessment

34. The basis of the Committee on Scientific Manpower's present assessment of the long-term demand for scientists and engineers derives from the belief, for which there is much circumstantial evidence, that there is a definable relationship between the rate of increase of industrial production on the one hand, and the number of trained scientists and engineers employed by industry on the other. In what follows an attempt is made to attach numerical values both to the ratio between changes in industrial output and changes in the number of scientists and engineers employed, and to a realistic assessment of the rates at which the economy as a whole, and the major sectors of industry separately, are likely to grow in the years ahead. By relating the one to the other, we have tried to assess the total number of scientists and engineers that might be required in industry, teaching and administration ten years hence; and also to assess the implications of this estimate in terms of the required annual output of engineers and scientists, in 1966 and 1970.

The relationship between the growth of the economy and the number of scientists and engineers in employment

35. In all countries which are in the forefront of industrial progress there is a tendency to increase the value of plant used per man employed, and the proportion of high-grade to low-grade staff. The tendency to employ more and more scientists and engineers in relation to the total labour force applies particularly to the most rapidly growing sectors of manufacturing industry. The precise nature of the relationship which prevails between the growth of a particular industry on the one hand (whether measured in terms of numbers employed, output or productivity), and its level of scientific employment on the other is, however, difficult to determine. It is also uncertain whether past and present trends in the relationship will necessarily continue unchanged into the future. In a few cases about which we have been given information, and which cover a period of some seven years, the ratio of increase in numbers of scientists and engineers employed to increase in output appears to have been in the neighbourhood of 1 : 1. A number of prominent industrialists whose views have been sought have independently suggested that something like a 1 : 1 ratio is likely to prevail in their own fields of production as these develop over the coming decade. This is supported by such statistical evidence as is available over a longer period about the trend in the number of scientists and engineers, and the trend of output, in individual industries.

36. Paragraphs 17–18 and Appendices III and IV show how the concentration of scientific manpower varies between industries. In some sectors (for example, the electrical industry, and chemical and allied trades) the proportion is high.

In others it is extremely low. Information bearing on the same point, and showing the large amount of variation which occurs even in different sectors of the engineering industry itself, was given in our previous report on the Recruitment of Engineers by this industry.* It is, of course, fair to recognise that needs will differ between one industry or section of an industry and another, and that there is no "right" proportion of qualified men for all industries. Even so, we are fully aware that if they are to survive in the face of modern competition, some sectors of British industry may have to raise their present low level of employment of scientific manpower at a rate faster than that at which their output is likely to rise. We also recognise that there will be a general need throughout industry to employ relatively larger numbers of trained scientific manpower with the increase in the use of automatic methods of control. And, lastly, we are fully conscious of the fact that it is impossible to forecast those kinds of technical development which might completely transform both the nature and the manpower requirements of industry in the long term.

37. In spite of these uncertainties, we have decided that it is more reasonable to base our projections of the likely need for scientific manpower on the assumption that demand within each industry will, on the average, increase in direct proportion to increases in industrial output than on some even more arbitrarily chosen relationship. Our answer should not, however, be regarded as implying more than the minimum level of supply of trained scientific manpower which, in our view, should be available at the end of the ten-year period that we are considering.

The rate of growth of the economy

38. We were advised that it would be appropriate to work on the basis of an average increase of industrial production at the rate of 4 per cent per annum. In the next decade little increase is expected in the number of workers in industry; the growth of production will depend upon increase in output per man-year. To achieve the postulated rate of growth, we are informed, would require the diversion of consumers' incomes to savings to a greater extent than at present in order to make possible a strong expansion of productive investment and exports. A greater rate of growth than 4 per cent would require correspondingly greater changes of the same kind. The extent and speed at which these economic adjustments can take place will depend upon political, economic and social considerations (both within and outside Britain) which we cannot judge. Our purpose has been to ensure that a 4 per cent rate of growth is rendered possible by an adequate supply of scientists and technologists.

39. An overall expansion of industrial output of 4 per cent a year is, of course, the weighted average of the contributions of the main industrial groups. In the chemical and engineering industries the annual rates of increase are assumed to be 7 per cent and 5¼ per cent respectively, whereas a much smaller increase of 2½ per cent per annum is assumed for the textile industry.

40. The assumed increase in output of each sector of industry has been used as a basis for calculating what the prospective demand will be for scientific manpower ten years hence.

The estimation of the present shortage in scientific manpower

41. The replies to the Ministry of Labour questionnaire provide an indication of the number of scientists and engineers who would be employed in three years' time, assuming that the men were available. Without qualification, the figures imply that the number of scientists and engineers who would be employed by manufacturing industry in 1959 would be 37 per cent greater than in 1956.

* Report on the Recruitment of Scientists and Engineers by the Engineering Industry (H.M.S.O., 1955).

42. It has been made clear by a number of firms that their demands for the three years to 1959 reflect a considerable margin for current shortages of qualified scientists and engineers, as well as allowing for "normal" increases in output and employment. We have tried to isolate the element of shortage by assuming that demand for trained manpower in each industry would at the very least rise, in relation to the number now employed, by the same proportion as output is expected to do over the next three years. This gives an estimate of manpower needs in 1959 without any allowance for current shortages. The difference between this estimate and the figures supplied by industry is then taken to represent the presumed current shortage. An allowance for this factor has, therefore, been added to the number currently employed, before making the extrapolations based on changes in output over the next ten years.

Method of estimating future demands

43. Our estimate of the future requirements of manufacturing industry has been calculated, in the way outlined in paragraph 42, by first making an appropriate addition to cover prevailing shortages in the existing stock of scientists and engineers in each major industrial group. This figure was then increased in direct proportion to the cumulative rate of growth which each industrial group is postulated to undergo over the next ten years. The result gives an estimate of demand for scientific manpower in 1966, in terms of the number of scientists and engineers, which we believe would be necessary to permit an increase in total industrial output amounting to 4 per cent per annum.

44. The estimates of future employment of scientists and engineers in the public sector of scientific employment have been dealt with separately. The estimates for Government Departments are based on existing policies and allow for only a very modest increase over the next ten years. In the field of education we have postulated sufficient teachers to deal with the increased number in secondary schools over the next ten years, but not for any further concentration on scientific subjects nor for any improvement in existing staffing ratios. A reasonable allowance for the latter would have been about 4,000 additional Science Graduates. Requirements of the universities are assumed to increase by about 100 per cent over the ten-year period.

45. We fully realise that we may have taken too conservative a view of the demand for scientific manpower that may develop in some parts of the public sector of the economy. On the other hand, we have not allowed for any decrease in our research effort for defence. On balance, it is reasonable to suppose that changes in demand by public authorities over the next ten years will not materially affect the order of magnitude of our final answer about the training of scientific manpower. Our concern is to provide an estimate of requirements which will be generally accepted as a minimum goal at which the universities and technical colleges can aim in the effort to provide for the increasing demand which is likely to develop in all sectors of the economy.

46. The broad conclusion of our calculations is that a condition essential to an annual rate of growth of 4 per cent in total industrial output is an increase in the number of qualified scientists and engineers employed from the present level of about 135,000 to somewhere in the region of 220,000 in 1966—an increase of rather over 60 per cent. In the strict sense of the definitions given in paragraph 6, the increase in requirements of engineers is estimated at about 70 per cent between 1956 and 1966, while the demand for scientists is expected to rise by about 50 per cent over the same period.

47. The order of magnitude of this projected increase in requirements of scientists and engineers is influenced by several factors, of which the most

important is the assumption that on an average the demand in each industry will increase in direct proportion to increases in output of that industry. We are, of course, aware that, in some industries, the number of trained scientific personnel is expected to increase at a faster rate than output—whether in an effort to catch up with present technical knowledge or, given that they are not technically backward, in adapting to as yet undefined technological developments. If this were to turn out to apply to British industry as a whole, our estimates of future demand would undoubtedly prove inadequate. But we have no reason to believe that this will be the case. Even though the same trend might well apply to certain backward sectors of industry, which in total are responsible for only a small part of the overall demand for scientific manpower, the most reasonable assumption, unless we turn entirely to guess work, is that an average ratio of 1 : 1 strikes a balance between industries in which trained manpower is likely to increase at a rate faster than output and those in which it will increase at a slower rate. The method followed in our calculations allows for the weighting of the final answer according to the greater volume of growth which it is assumed those industries (e.g. the chemical) that are now relatively strong in scientific manpower will undergo relative to others which are weak.

The annual flow of qualified scientists and engineers required in 1966 and 1970

48. It is extremely difficult to translate our estimates of future demands into figures of annual flow. The difficulty is that we do not know what proportion of all scientists and engineers who obtain university degrees, or, in the case of engineers, who obtain equivalent qualifications, actually take up employment in Great Britain, and what proportion should be classified as overseas students, British students who emigrate, women graduates who are not employed except in the home, or science graduates who take up occupations that are not normally classified under the headings of science or engineering. Nevertheless, for practical purposes it is essential that we obtain some idea of the gross flow of people qualified in pure and applied science which would be compatible with a 1966 employment figure of the order of 220,000. Today the annual gross flow from the universities and technical colleges is a little over 10,000 in the sense of people taking first degrees or equivalent qualifications in the subjects listed in paragraph 6—about half of these are scientists and half engineers. Of the latter under half are university graduates. There are already signs of an increase in student numbers, and it may well be that the flow will rise to 12,000 by 1958/59, so that over the next five years our universities and technical colleges might turn out some 60,000 people qualified in science and engineering. If we make reasonable allowances for emigration, overseas students, etc., the average annual flow for the following five years would have to reach 16,000 if the stock of scientists and engineers were to increase to 220,000 by 1966. This would represent a remarkable educational achievement. Caution demands that we assume that there will still be a shortage of scientific manpower, and particularly of engineers ten years hence.

49. In fact, no one can predict the rates at which the annual flow of newly qualified people and of the total stock of scientists and engineers in employment are likely to increase. The best we can do is to calculate what the net intake should be in order to allow for a continued growth of production after 1966, assuming a stock of scientists and engineers at that date of 220,000, and to add to it an allowance of 25 per cent for overseas students, emigration, etc., as well as for the continuation of some measure of shortage. The result provides some idea of what the annual flow would have to be in order to enable industrial production to continue to increase at a rate of 4 per cent per annum. A figure can be similarly calculated for 1970 on the assumption that production continues to increase at about the same rate, and that the stock of scientists and engineers rises between 1966 and 1970 in accordance with our estimate of requirements.

50. The result of these calculations is summarised very briefly below:

Annual output of qualified scientists and engineers

	Thousands
1954/55	10·3
Estimated requirements	
1966	16·9
1970	19·9

Thus the projections suggest that the number of people qualifying each year in science and engineering would need to increase from about 10,000 in 1954/55 to about 20,000 in 1970—an increase of about 100 per cent.

51. Our reservations about advancing precise estimates of the required flow of properly qualified scientific and engineering manpower in 1966 and 1970 apply with even greater force to any attempts that might be made to provide figures for scientists and engineers separately. The two categories are distinct only in the way defined in paragraph 6 and, in practice, overlap at many points. Many people who have been trained as physicists work as electrical engineers or metallurgists, and others who have taken a university degree as chemists become chemical engineers. In the light of present developments in the education of engineers and also of "pure" scientists, it would be hazardous to try to define the relationship of these two classes ten years hence. All that we can say with certainty is that the increase in output that will be required over the next ten years or so is likely to be very much greater for men and women trained in the engineering than in the basic sciences.

The source of students

52. If this rate of flow is to materialise, higher education in science and engineering will have to continue to develop at least as vigorously in the second post-war decade as it did in the first. Such a rate of flow also requires that the proportion of each age group which proceeds to a higher education in the sciences (now a little over 1 per cent) will not fall, and may even have to rise, as the post-war increases in births raise the numbers between 18 and 20 in the population. If the proportion were to remain the same as today, the absolute increase would be from 8,660 new university students in science and technology in 1955/56 to about 13,000 in 1966/67, in addition to the numbers entering advanced courses at the technical colleges. The increase would, of course, be greater, the greater the shift from the humanities to science. Further, in our 1952 report (Cmd. 8561) we strongly advocated, as a matter of national policy, that every encouragement should be given to increasing the proportion of each age group who stay on at school until the pre-university year. At that time the figure was 7 per cent. Today it is about 9 per cent, and on the assumption that present trends continue, it would rise to about 15 per cent by 1966 or 1967. We do not doubt that enough talented boys and girls will be available, if they choose to take up careers in science and engineering, to be trained at the rates which we recommend should be the basis of national policy. This, of course, assumes that facilities for secondary education are adequate.

The future pattern of the Universities and Technical Colleges

53. It is for the University Grants Committee and the Education Departments to consider how these likely demands for graduates in pure and applied science are to be met. The expansion which has already taken place in the technical colleges is not fully reflected in the current annual figures of newly qualified technologists, because a good number of students have to spend some time in

acquiring the additional academic qualifications or practical experience needed for membership of a professional institution. This expansion, coupled with the five-year programme initiated this year, should produce a substantial increase in the number of professional engineers educated at technical colleges. Their quality should at least be maintained, and may be expected to improve as a result of the growth of sandwich courses and the creation of the new award of Diploma in Technology. These are welcome developments, but it is our view that, provided it does not involve a lowering of their standards, the universities should attempt to carry as much as possible of the burden of expansion required to meet the estimate that we have made of the likely, even if minimum, demands for professional scientists and engineers. There is, in our view, little risk that the greatest possible combined efforts of the universities and technical colleges will result in any over-production of professional scientists and engineers during the 1960's.

Conclusion

54. Projections of the kind with which this section of the Report is concerned are essentially a guide to action, and not a form of prophecy about the scientific content of British industry ten years hence. The merit of our present assessment is not that it may provide a better picture of future needs for scientific manpower than have our previous reviews, but that it starts off with a better picture of the employment of scientists and engineers today. Even so, and as we have already made clear, we are fully aware that there are gaps in our knowledge about the existing situation. For that reason the Committee on Scientific Manpower proposes to maintain and extend the supply of information bearing on this matter. We realise that the figures for the present stock of scientists and engineers in manufacturing industry may still be subject to some margin of error, and that we have no knowledge of the precise proportion of science graduates who take up work in their respective fields of study in Great Britain. We know that our figures about scientific employment in the public sector of the economy, including teaching, reflect current policy which may well differ from future policy. And we have no illusions about the sanctity of the notion that, on average, the number of scientists and engineers employed in industry will increase in proportion to increases in output. All we have done is to decide that such a view is better than any other on which we could have based our calculations. In consequence we are satisfied that it points to a reasonable goal at which universities and technical colleges should aim.

55. The correlation between increases in industrial output and increases in the numbers of scientists in employment is more than fortuitous. Modern science, whether basic or engineering science, is the source of almost all the ideas on which the development of modern industry depends, and certainly the source of all the more important ideas. We cannot foretell what scientific or technological developments are likely to transform industry in the future; but we can say that scientists and technologists are an essential condition to the healthy growth of industry, now and in the future. Adequate numbers of properly trained men are thus critical for the maintenance and improvement of Britain's present position in the face of increasing technological and business competition from abroad.

56. The statements made by industrialists about their need for scientific manpower should be seen, at least for the next decade, as statements of intention; statements that without scientists and engineers manufacturers cannot transform the character and also the scale of their operations. At the national level, the conclusion that over the next ten to fifteen years we should aim at an annual figure of "graduations" in pure and applied science of about 20,000, as compared

with 10,000 today, is a statement of a minimum goal which needs to be achieved if the economy is to grow at an acceptable rate. If the universities and technical colleges can achieve more, so much the better. We are reluctant to believe that less could be accepted as a target.

APPENDIX I

For the purpose of this report the term "qualified scientists and engineers" includes, in addition to university graduates, corporate and graduate members of the following professional institutions; and associates of the educational institutions listed below.

A. List of Professional Institutions

The Royal Aeronautical Society
The Institution of Chemical Engineers
The Royal Institute of Chemistry
The Institution of Civil Engineers
The Institution of Electrical Engineers
The Institution of Gas Engineers
The Institute of Marine Engineers
The Institution of Mechanical Engineers
The Institution of Metallurgists
The Institution of Mining and Metallurgy
The Institution of Municipal Engineers
The Institution of Naval Architects
The Institute of Physics
The Institution of Production Engineers
The Institution of Structural Engineers

B. List of Educational Institutions

The Camborne School of Mines
The City and Guilds of London Institute
The Heriot-Watt College
The Manchester College of Technology
The Royal College of Science (London)
The Royal College of Science (Ireland)
The Royal School of Mines
The Royal Technical College, Glasgow

APPENDIX II

SCIENTISTS AND ENGINEERS EMPLOYED IN GREAT BRITAIN IN EARLY 1956

	Industry					Central Government	Local authorities	Education[4]	Grand Total
	Manufacturing industry[1]	Building and contracting[1]	Industrial Research Associations	Nationalised industries[2]	Total industry[3]				
Qualified Scientists									
Biologists	280	—	31	9	320	1,117	20	3,381	4,838
Chemists	11,256	19	469	1,451	13,195	1,626	228	5,643	20,692
Geologists	75	50	9	120	254	183	15	442	894
Mathematicians	1,149	3	60	175	1,387	765	28	9,302	11,482
Physicists	3,301	3	348	660	4,312	1,402	19	4,751	10,484
Others	—	—	—	—	—	705	42	2,091	2,838
Total Qualified Scientists	16,061	75	917	2,415	19,468	5,798	352	25,610	51,228
Qualified Engineers									
Metallurgists	2,683	3	114	214	3,014	189	6	90	3,299
Chemical Engineers	1,218	—	26	191	1,435	63	11	48	1,557
Civil and Structural Engineers	1,561	3,332	39	1,242	6,174	1,179	5,381	151	12,885
Electrical Engineers	9,165	86	67	5,312	14,630	2,958	233	1,712	19,533
Mining Engineers	151	161	6	3,316	3,634	99	34	83	3,850
Mechanical and other Engineers	17,990	161	228	4,388	22,767	3,556	664	345	27,332
Total Qualified Engineers	32,768	3,743	480	14,663	51,654	8,044	6,329	2,429	68,456
TOTAL QUALIFIED SCIENTISTS AND ENGINEERS	48,829	3,818	1,397	17,078	71,122	13,842	6,681	28,039	119,684
Holders of H.N.C., H.N.D., etc., only									
Electrical Engineers	6,363	167	32	3,295	9,857	725	129	—	10,711
Mechanical Engineers	15,927	234	69	2,032	18,262	985	190	—	19,437
Total with H.N.C., H.N.D., etc., only	22,290	401	101	5,327	28,119	1,710	319	—	30,148

[1] Excluding establishments with under 100 total employees.
[2] British Airways Corporations (B.E.A. and B.O.A.C.), Atomic Energy Authority, British Transport Commission (British Railways, London Transport Executive and Docks Division only), Central Electricity Authority and Scottish Electricity Boards, Gas Council and Area Boards, and National Coal Board.
[3] Excluding mining (private firms), distribution, transport (private firms), shipping, other service industries (including consultants, etc., working on their own account) and manufacturing establishments with under 100 total employees.
[4] Schools, technical colleges and universities.

APPENDIX III

TABLE I.—QUALIFIED SCIENTISTS AND ENGINEERS EMPLOYED IN 1956, ANALYSED BY TYPE OF WORK AND RELATED TO TOTAL EMPLOYMENT, AND ESTIMATED REQUIREMENTS IN 1959

Manufacturing Industry

Industry[1]	Research and Development	Manufacture, etc.[2]	Other work	TOTAL QUALIFIED SCIENTISTS AND ENGINEERS	Total number employed in the industry[3] December, 1955 (Thousands)	Scientists and engineers as percentage of total employed	Distribution of scientists and engineers between industries (per cent)	Percentage increase in 1959 requirements over 1956
Order								
III Treatment of non-metalliferous mining products (bricks, china, glass, cement, etc.)	246	483	23	752	226	0·3	1·6	43·4
IV (*a*) Chemicals and allied trades (other than oil refining) (FE, FBC, FBP, FA, FH, FDS and FDZ)	3,935	3,769	620	8,324	310	2·7	17·0	20·4
IV (*b*) Mineral oil refining (FDM)	461	719	123	1,303	25	5·2	2·7	47·5
V (*a*) Metal manufacture—Iron and steel (GA, GC, CE, GH, GP)	483	1,417	108	2,008	405	0·5	4·1	38·0
V (*b*) Non-ferrous metals (GF)	335	663	130	1,128	104	1·1	2·3	37·0
VI (*a*) Shipbuilding and ship-repairing and marine engineering (BC and CT)	69	617	89	775	214	0·4	1·6	10·7
VI (*b*) Agricultural machinery (except tractors) (CDA)	6	45	24	75	20	0·4	0·2	16·0
VI (*c*) Other plant and machinery (except electrical) (CDB, CDM, CDS, CDT, CDO, CDX)	2,014	3,914	726	6,654	687	1·0	13·6	38·3
VI (*d*) Constructional engineering (CZ)	98	721	29	848	57	1·5	1·7	36·8
VI (*e*) Electrical engineering (CN, GKW, GKT, GKR, GKL, GKB and GKZ)	7,056	3,579	1,563	12,198	600	2·0	25·0	43·2
VII (*a*) Motor vehicles and cycles, carts, perambulators (excluding garages) (DAM, DAP and DB)	806	1,165	141	2,112	503	0·4	4·3	36·1
VII (*b*) Aircraft (DAA)	3,359	851	49	4,259	226	1·9	8·7	52·3
VII (*c*) Railway equipment (CDR, CDL and DE)	10	157	36	203	47	0·4	0·4	23·6
VIII Other metal goods	295	1,252	101	1,648	327	0·5	3·4	33·1
IX Precision instruments, jewellery, clocks, etc.	496	188	77	761	88	0·9	1·6	60·1
X (*a*) Cotton (VAS, VAW)	68	83	12	163	208	0·1	0·3	48·5
X (*b*) Wool textiles (VB)	32	76	14	122	158	0·1	0·3	13·1
X (*c*) Rayon, nylon, etc. (VD, VE)	472	328	46	846	78	1·1	1·7	35·9
X (*d*) and XI Other textiles and leather	201	675	16	892	278	0·3	1·8	25·5
XII Clothing	11	37	2	50	327	0·02	0·1	50·0
XIII Food, drink, tobacco	426	1,157	81	1,664	540	0·3	3·4	25·5
XIV and XV Wood, cork, paper and printing	339	479	18	836	482	0·2	1·7	48·3
XVI Other manufacturing (e.g. rubber, plastics, sports goods, films, etc.)	516	616	76	1,208	215	0·6	2·5	41·1
TOTAL MANUFACTURING	21,734	22,991	4,104	48,829	6,125	0·8	100·0	37·2

[1] The industrial analysis is based on the Orders of the *Standard Industrial Classification*. Some Orders have been subdivided, the contents of the subdivision being shown by the Industry Code Letters (also taken from the *Standard Industrial Classification*) quoted in brackets.
[2] Manufacture, production, operation, maintenance and installation.
[3] Excluding establishments with under 100 total employees.

APPENDIX III

TABLE II.—QUALIFIED SCIENTISTS AND ENGINEERS EMPLOYED IN 1956, ANALYSED BY TYPE OF WORK AND RELATED TO TOTAL EMPLOYMENT, AND ESTIMATED REQUIREMENTS IN 1959

Nationalised Industries

Nationalised Industry	Research and Development	Operation, maintenance, etc.	Other work	Total Qualified Scientists and Engineers	Total number employed in the industry	Scientists and engineers as percentage of total employed	Percentage increase in 1959 requirements over 1956
Airways Corporations (B.E.A. and B.O.A.C.)	53	92	3	148	28,000	0·5	11·5
Atomic Energy Authority	1,706	717	44	2,467	22,600	10·9	..[4]
British Transport Commission[1]	172	1,015	364	1,551	670,400	0·23	31·0
Central Electricity Authority and Scottish Electricity Boards	..[2]	..[2]	..[2]	5,870	200,500	2·9	9·5
Gas Council and Area Gas Boards ..	150	1,513	112	1,775	142,350	1·2	23·5
National Coal Board	445	4,822	—	5,267	785,000	0·7	31·0
TOTAL	2,526[3]	8,159[3]	523[3]	17,078	1,848,850	0·9	..

[1] British Railways, London Transport Executive and Docks Division only.
[2] Figures for distribution by type of work are not available for Electricity Authorities.
[3] Excluding Electricity Authorities.
[4] See Note (1) to Appendix IV, Table II.

APPENDIX IV

TABLE I.—SCIENTISTS AND ENGINEERS EMPLOYED IN 1956 AND ESTIMATED REQUIREMENTS IN 1959, ANALYSED BY PROFESSION

Manufacturing, building and research associations

Industry[1]	Year	QUALIFIED SCIENTISTS AND ENGINEERS												WITH H.N.C. OR H.N.D. ONLY	
		Biologists	Chemists	Geologists	Mathematicians	Physicists	Metallurgists	Chemical engineers	Civil and structural engineers	Electrical engineers	Mining engineers	Mechanical and other engineers	TOTAL QUALIFIED	Electrical engineers	Mechanical and other engineers
Order III Treatment of non-metalliferous mining products (bricks, china, glass, cement, etc.)	1956	1	247	13	9	89	14	20	50	63	21	225	752	51	165
	1959	1	356	13	13	145	19	30	79	90	21	311	1,078	—	—
IV (*a*) Chemicals and allied trades (other than oil refining) (FE, FBC, FBP, FA, FH, FDS and FDZ)	1956	191	5,464	3	46	248	71	590	163	237	23	1,288	8,324	126	649
	1959	221	6,456	2	54	314	88	794	172	276	21	1,622	10,020	—	—
IV (*b*) Mineral oil refining (FDM)	1956	—	540	49	1	77	5	142	54	43	—	392	1,303	23	118
	1959	—	833	56	4	102	7	255	67	57	—	541	1,922	—	—
V (*a*) Metal manufacture—Iron and steel (GA, GC, GE, GH, GP)	1956	5	161	—	15	37	916	17	56	138	10	653	2,008	125	680
	1959	10	255	—	19	60	1,205	30	87	204	13	888	2,771	—	—
V (*b*) Non-ferrous metals (GF)	1956	1	278	1	3	22	457	14	6	45	1	300	1,128	35	242
	1959	1	356	1	6	40	621	16	8	66	1	429	1,545	—	—
VI (*a*) Shipbuilding and ship-repairing and marine engineering (BC and GT) ..	1956	—	4	—	4	—	16	—	43	19	—	689	775	42	522
	1959	—	5	—	4	—	19	—	43	23	—	764	858	—	—
VI (*b*) Agricultural machinery (except tractors) (CDA)	1956	—	2	—	—	—	5	—	7	—	—	61	75	1	62
	1959	—	2	—	—	—	5	—	10	1	—	69	87	—	—
VI (*c*) Other plant and machinery (except Electrical) (CDB, CDM, CDS, CDT, CDO, CDX).	1956	1	274	1	116	195	342	155	126	602	66	4,776	6,654	557	4,806
	1959	1	365	1	170	267	484	245	174	898	69	6,526	9,200	—	—
VI (*d*) Constructional engineering (CZ)	1956	—	21	—	14	16	7	46	543	46	2	153	848	22	199
	1959	1	27	1	42	22	9	57	708	66	4	223	1,160	—	—
VI (*e*) Electrical engineering (CN, GKW, GKT, GKR, GKL, GKB and GKZ)	1956	1	693	2	281	1,897	367	37	13	7,088	10	1,809	12,198	4,524	2,042
	1959	1	921	1	408	2,614	579	65	20	9,855	11	2,998	17,473	—	—
VII (*a*) Motor vehicles and cycles, carts, perambulators (DAM, DAR, DAP and DB) ..	1956	—	104	—	35	28	110	29	7	76	2	1,721	2,112	119	2,313
	1959	—	134	—	67	49	134	48	5	126	2	2,310	2,875	—	—

VII (*b*)	Aircraft (DAA)	1956	—	46	—	466	195	86	3	32	245	—	3,186	4,259	246	1,984
		1959	—	71	—	750	357	152	5	61	442	—	4,750	6,588	—	—
VII (*c*)	Railway equipment (CDR, CDL and DE)	1956	1	2	—	1	3	10	2	9	20	—	155	203	28	132
		1959	1	2	—	2	5	13	2	16	21	—	189	251	—	—
VIII	Other metal goods	1956	1	164	4	23	12	236	28	355	82	—	743	1,648	106	708
		1959	1	155	4	32	18	344	31	504	118	—	986	2,193	—	—
IX	Precision instruments, jewellery, clocks, etc.	1956	—	73	—	30	138	38	16	2	192	—	272	761	103	243
		1959	—	104	—	49	246	62	36	6	302	—	413	1,218	—	—
X (*a*)	Cotton (VAS, VAW)	1956	—	65	—	6	17	—	—	—	13	—	62	163	11	113
		1959	—	98	—	7	23	—	—	—	32	—	82	242	—	—
X (*b*)	Wool textiles (VB)	1956	—	57	—	—	4	—	4	—	4	—	53	122	6	7
		1959	—	61	—	—	10	—	8	—	4	—	55	138	—	—
X (*c*)	Rayon, nylon, etc. (VD, VE)	1956	—	502	—	31	102	—	35	5	42	1	128	846	22	52
		1959	—	648	—	32	138	1	53	5	68	1	204	1,150	—	—
X (*d*) and XI	Other textiles and leather	1956	—	588	—	3	13	3	3	8	14	—	260	892	33	145
		1959	—	752	—	6	25	4	8	7	25	—	292	1,119	—	—
XII	Clothing	1956	—	25	—	—	—	—	1	—	3	—	21	50	14	19
		1959	—	32	—	—	—	—	1	—	11	—	31	75	—	—
XIII	Food, drink, tobacco	1956	76	938	2	34	36	—	35	29	52	10	452	1,664	30	237
		1959	84	1,187	2	35	50	—	46	31	84	10	560	2,089	—	—
XIV and XV	Wood, cork, paper, printing	1956	2	302	—	26	92	—	14	41	81	4	274	836	84	213
		1959	2	457	—	55	134	8	33	61	117	4	369	1,240	—	—
XVI	Other manufacturing (e.g., rubber, plastics, sports goods, films, etc.)	1956	—	706	—	5	80	—	27	12	60	1	317	1,208	55	276
		1959	—	1,001	—	8	120	—	42	22	93	1	418	1,705	—	—
	TOTAL MANUFACTURING	1956	280	11,256	75	1,149	3,301	2,683	1,218	1,561	9,165	151	17,990	48,829	6,363	15,927
		1959	324	14,278	81	1,763	4,739	3,754	1,805	2,086	12,979	158	25,030	66,997	—	—
	Building and contracting	1956	—	19	50	3	3	3	—	3,332	86	161	161	3,818	167	234
		1959	—	44	58	3	3	8	—	4,207	214	172	249	4,958	—	—
	Industrial research associations ..	1956	31	469	9	60	348	114	26	39	67	6	228	1,397	32	69
		1959	28	539	8	80	427	157	35	49	88	12	317	1,740	3	39
	TOTAL FOR MANUFACTURING, BUILDING AND CONTRACTING, AND INDUSTRIAL RESEARCH ASSOCIATIONS.	1956	311	11,744	134	1,212	3,652	2,800	1,244	4,932	9,318	318	18,379	54,044	6,562	16,230
		1959	352	14,861	147	1,846	5,169	3,919	1,840	6,342	13,281	342	25,596	73,695	3	39

[1] The industrial analysis is based on the Orders of the *Standard Industrial Classification*. Some Orders have been subdivided, the contents of the subdivisions being shown by the Industry Code Letters (also taken from the *Standard Industrial Classification*) quoted in brackets.

APPENDIX IV

TABLE II—SCIENTISTS AND ENGINEERS EMPLOYED IN 1956 AND ESTIMATED REQUIREMENTS IN 1959, ANALYSED BY PROFESSION

Nationalised Industries

Nationalised Industry	Year	QUALIFIED SCIENTISTS AND ENGINEERS											WITH H.N.C. OR H.N.D. ONLY	
		Biologists	Chemists	Geologists	Mathematicians	Physicists	Metallurgists	Chemical engineers	Civil and structural engineers	Electrical engineers	Mining engineers	Mechanical and other engineers	TOTAL QUALIFIED	Electrical engineers	Mechanical and other engineers
Airways Corporations (B.E.A. and B.O.A.C.) ..	1956	—	—	—	6	—	—	—	6	5	—	131	148	8	68
	1959	—	—	—	6	—	—	—	6	7	—	146	165	..	..
Atomic Energy Authority[1]	1956	4	741	—	132	539	182	103	103	221	3	439	2,467	103	262
	1959	5	963	—	172	701	237	134	134	287	4	558	3,195	..	..
British Transport Commission[2]	1956	—	61	1	3	11	15	—	613	245	4	598	1,551	201	322
	1959	—	71	1	3	12	17	1	881	337	5	703	2,031	..	..
Central Electricity Authority and Scottish Electricity Boards	1956	3	160	—	—	12	11	4	280	4,500	—	900	5,870	2,200	260
	1959	3	185	—	—	22	14	6	330	4,870	—	1,000	6,430	..	..
Gas Council and Area Gas Boards	1956	—	250	—	8	24	—	69	53	18	—	1,353	1,775	14	231
	1959	—	323	—	9	30	—	86	71	36	—	1,638	2,193	..	..
National Coal Board	1956	2	239	119	26	74	6	15	187	323	3,309	967	5,267	769	889
	1959	2	312	132	37	141	8	40	243	420	4,302	1,257	6,894	..	..
TOTAL NATIONALISED INDUSTRIES	1956	9	1,451	120	175	660	214	191	1,242	5,312	3,316	4,388	17,078	3,295	2,032
	1959	10	1,854	133	227	906	276	267	1,665	5,957	4,311	5,302	20,908	..	..

[1] The 1959 requirements of the Atomic Energy Authority for scientists and engineers cannot be given for security reasons. An arbitrary increase by 1959 of 30 per cent over 1956 has been assumed.
[2] British Railways, London Transport Executive and Docks Division.

APPENDIX IV

TABLE III.—SCIENTISTS AND ENGINEERS EMPLOYED IN 1956 AND ESTIMATED REQUIREMENTS IN 1959, ANALYSED BY PROFESSION

Public authorities (excluding education)[1, 2]

	Year	QUALIFIED SCIENTISTS AND ENGINEERS													WITH H.N.C. OR H.N.D. ONLY	
		Biologists	Chemists	Geologists	Mathematicians	Physicists	Other scientists	Metallurgists	Chemical engineers	Civil and structural engineers	Electrical engineers	Mining engineers	Mechanical and other engineers	TOTAL QUALIFIED	Electrical engineers	Mechanical and other engineers
Central Government																
Defence Departments ..	1956	58	725	—	544	954	135	144	45	688	1,542	3	2,768	7,606	528	812
	1959	61	740	—	599	1,066	160	161	52	752	1,760	3	3,118	8,472	645	972
Civil Departments	1956	449	352	38	76	158	407	23	8	421	1,335	96	519	3,882	189	102
	1959	503	420	51	104	190	411	28	10	494	1,534	127	574	4,446	342	146
Research Departments ..	1956	610	549	145	145	290	163	22	10	70	81	—	269	2,354	8	71
	1959	857	679	179	164	335	179	25	16	81	93	—	311	2,919	10	91
TOTAL	1956	1,117	1,626	183	765	1,402	705	189	63	1,179	2,958	99	3,556	13,842	725	985
	1959	1,421	1,839	230	867	1,591	750	214	78	1,327	3,387	130	4,003	15,837	997	1,209
Local Authorities	1956	20	228	15	28	19	42	6	11	5,381	233	34	664	6,681	129	190
	1959	27	286	19	28	22	45	8	13	6,838	295	50	822	8,453	154	226

[1] Excluding departments having less than 50 scientists and engineers. The omission does not significantly affect the total figures.
[2] Excluding H.M. Oversea Civil Service.

APPENDIX IV

TABLE IV.—QUALIFIED SCIENTISTS AND ENGINEERS EMPLOYED IN 1956 AND ESTIMATED REQUIREMENTS IN 1959, ANALYSED BY PROFESSION

Education (public and private)

	Year	Biologists	Chemists (excluding pharmacists)	Geologists	Mathematicians	Physicists	Other scientists	Metallurgists	Chemical engineers	Civil and structural engineers	Electrical engineers	Mining engineers	Mechanical and other engineers	Total Qualified scientists and engineers
Universities[1]	1956	574	758	199	431	428	—	86	48	151	153	83	345	3,256
	1959	690	1,050	260	520	580	—	150	100	190	210	110	480	4,340
Schools and Technical Colleges														
England and Wales	1956	2,479	3,759	241	6,773	3,068	2,011	—			1,333[2]			19,664
	1959	2,509	3,976	288	7,082	3,238	2,210	—			1,500[2]			20,803
Scotland	1956	328	1,126	2	2,098	1,255	80	4			226[2]			5,119
	1959	360	1,297	2	2,459	1,440	90	4			255[2]			5,907
TOTAL SCHOOLS	1956	2,807	4,885	243	8,871	4,323	2,091	4			1,559[2]			24,783
	1959	2,869	5,273	290	9,541	4,678	2,300	4			1,755[2]			26,710
Total Universities, Schools and Technical Colleges	1956	3,381	5,643	442	9,302	4,751	2,091	90			2,339			28,039
	1959	3,559	6,323	550	10,061	5,258	2,300	154			2,845			31,050

[1] Requirements in 1959 were estimated before the University Grants Committee had received the Universities' estimates for 1957–62 and are conjectural.
[2] No figures are available for different kinds of engineers,

APPENDIX V

NOTE ON THE SAMPLING ARRANGEMENTS

The Social Survey sent the enquiry forms to a sample of establishments in manufacturing industry selected at random from the list of those which supply the Ministry of Labour periodically with information about employment. The sample included all establishments at which 500 or more persons are employed; one-quarter of all establishments with between 200 and 499 workers; and one-twelfth of all establishments with between 100 and 199 workers. Establishments with less than 100 workers were excluded from the Survey.

Of the establishments approached, 85 per cent co-operated by supplying information.

It was assumed throughout that the proportion of scientists and engineers to the total number of employees at the establishments which supplied information was representative of the whole industry, and the estimates for each industry were made on this basis.

The sampling fractions in the building and contracting industry were one-half of the firms with 500 workers or more; one-eighth of the firms with 250–499 workers; and one-twentyfourth of the firms with 100–249 workers. The estimates were made on the same basis as for manufacturing industry.

APPENDIX VI

ADVISORY COUNCIL ON SCIENTIFIC POLICY
COMMITTEE ON SCIENTIFIC MANPOWER

Membership of the Committee

Professor Sir SOLLY ZUCKERMAN ..	Chairman
Sir FREDERICK BRUNDRETT	Chairman, Defence Research Policy Committee
Mr. R. W. B. CLARKE	H. M. Treasury
Sir JOHN COCKCROFT	Director, Atomic Energy Research Establishment
Sir HAROLD ROXBEE COX	Director, Wilmot Breeden Ltd. Director, The Brush Group Ltd.
Sir GILBERT FLEMMING	Secretary, Ministry of Education
Mr. A. J. S. JAMES	Ministry of Labour and National Service
Mr. E. D. T. JOURDAIN	Office of the Lord President of the Council
Sir KEITH MURRAY	Chairman, University Grants Committee
Sir WILLIAM MURRIE	Secretary, Scottish Education Department
Sir EWART SMITH	A Deputy Chairman, Imperial Chemical Industries Ltd.
Dr. C. P. SNOW	Civil Service Commission

Secretary

Mrs. E. H. BOOTHROYD	Office of the Lord President of the Council

Note:

The Committee on Scientific Manpower was assisted by a Technical Sub-Committee under the Chairmanship of Mr. C. T. Saunders, Deputy Director of the Central Statistical Office. The following Departments were represented on the Sub-Committee:—Lord President's Office. Treasury, Ministry of Labour and National Service, Ministry of Education and the University Grants Committee.